The High-Resolution Rapid Refresh (HRRR) – Smoke modeling system

The HRRR-Smoke model is based on the Weather Research and Forecasting model coupled to Chemistry (WRF-Chem, http://ruc.noaa.gov/wrf/WG11/). The dynamics and physics packages and settings for the meteorology of HRRR-Smoke are based on the experimental version of the HRRR model, which is run in real-time (http://rapidrefresh.noaa.gov/hrrr/) at NOAA/ESRL Global Systems Division (GSD). HRRR-Smoke has been developed to simulate the emissions and transport of smoke from wildfires in real time in high spatial resolution. Since HRRR-Smoke includes anthropogenic emissions of other particulate matter species, and includes an aerosol aware microphysics scheme, we will also look at aerosol impacts on Numerical Weather Prediction (NWP).

The fire emissions are calculated using the fire detection and characterization data from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on the Suomi National Polar-orbiting Partnership satellite. Fire Radiative Power (FRP) data from VIIRS determine fire size and are then applied in HRRR-Smoke to calculate injection heights using a plume rise model. The real-time VIIRS data is provided by NOAA/NESDIS Center for Satellite Applications and Research.

A simple Gaussian profile is used to determine the diurnal cycle of the fire emissions in the model. Thus, temporal variability of the simulated smoke concentrations in each forecast depends on varying fire emissions, plume rise, also transport of smoke by wind and turbulent mixing, and removal processes.

Currently HRRR-Smoke is run in real time by NOAA/ESRL/GSD for the CONUS domain (3km horizontal grid resolution). HRRR-Smoke is initialized every day at 00, 06, 12 and 18UTC using input files for the meteorology from the real-time HRRR experimental runs. The model is then run to produce 36 hour forecasts.

The development of the HRRR-Smoke modeling system is conducted in collaboration with Saulo Freitas (NASA) and Gabriel Pereira (Brazil). This work is funded by the JPSS Proving Ground program (www.jpss.noaa.gov/community_proving-ground.html).

Ongoing developments:

- Adding more graphics for the smoke visualization on the web-page;
- Updating physics packages;
- Display smoke feedback on radiation and microphysics;

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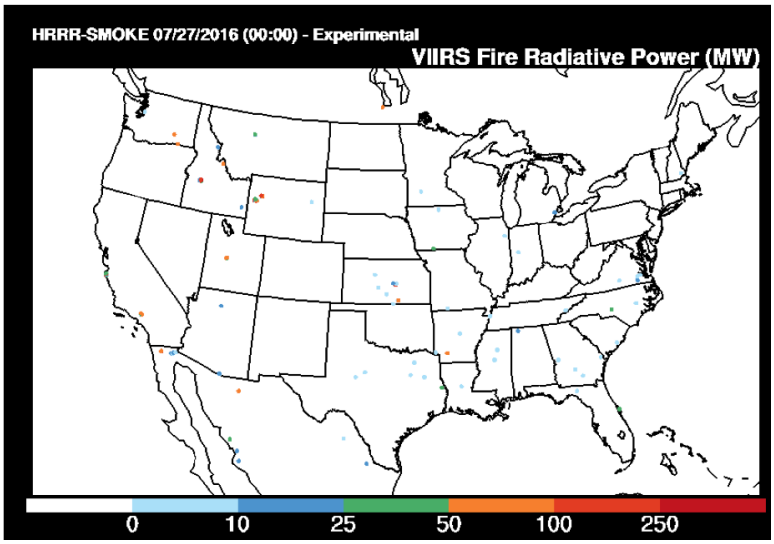
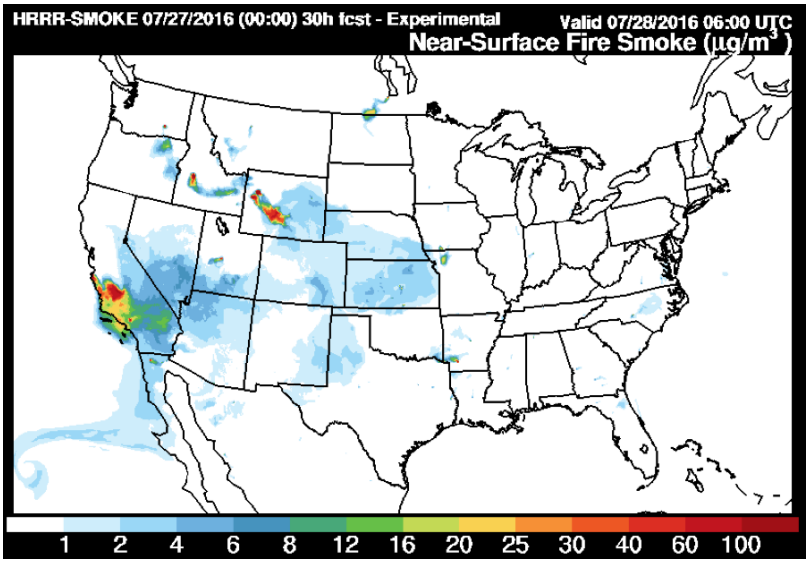
Below we describe the plots shown on the web-site.

The "Fire Radiative Power" plots: These FRP data are processed during HRRR-Smoke initialization by processing FRP for the model domain detected during previous 24 hours by VIIRS. Then the model simulates fire emissions and plume rise using the static FRP fields for 36 hours of smoke forecast. For instance, the following plot shows processed FRP values from VIIRS for the model grid cells (each size of 3x3 km) containing fires for July 27th, 2016 experimental smoke forecast.



The "near surface fire smoke" plots: This plot shows simulated fire emitted fine particulate matter (PM2.5 or fire smoke) concentrations at the first model level (~8m above ground). The following plot shows forecast of near-surface fire smoke for July 28th, 0600 UTC over the CONUS domain. This forecast is based on the model simulation of 30 hours from the model initialization time, which is 0000 UTC on July 27th.



The "vertically integrated fire smoke" plots: This plot shows simulated total PM2.5 mass within vertical columns over each model grid cell (or fire smoke). These columns reach as high as ~25 km above ground. The purpose of showing such plots is to display the effect of fire smoke load which includes smoke in boundary layer as well as aloft, illustrating the integral effect of fire smoke throughout the atmosphere. The following plot shows a forecast of vertically integrated fire smoke, based on the model simulation of 30 hours from the model initialization time, which is 0000UTC on July 27th.